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EFFECTS OF TRAINING TASK REPETITION ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

Joseph D. Hagman

TRAINING TECHNICAL AREA

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 9 Research Report 1271	2. GOVT ACCESSION NO. AD-A101	3. RECIPIENT'S CATALOG NUMBER 859
4. TITLE (and Subtitle) 6 EFFECTS OF TRAINING TASK REPETITION ON RETENTION AND TRANSFER OF MAINTENANCE SKILL 10	5. TYPE OF REPORT & PERIOD COVERED	
7. AUTHOR(s) Joseph D. Hagman	8. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 22333	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 2Q263743A794	
11. CONTROLLING OFFICE NAME AND ADDRESS Deputy Chief of Staff for Training Army Training and Doctrine Command Fort Eustis, Virginia 23604	11	12. REPORT DATE May 1980 12 4/10
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 14 ARI-RR-1271	13. NUMBER OF PAGES 32	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited.	15. SECURITY CLASS. (of this report) Unclassified	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Training Retention Repetition Transfer Maintenance Skill Performance Aids		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) To help guide training course revision efforts of the United States Army Ordnance Center and School (USAOCS), the present experiment examined effects of training task repetition on retention and transfer of maintenance skill. Five groups of 15 student Fuel and Electrical Repairmen, 63G military Occupational Specialty (MOS), performed from zero to four repetitions on testing charging system electrical output using the 500A Sun Test Stand. Each group received test stand familiarization instruction followed by one level of task repetition.		

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Retention was tested immediately and 14 days after training. Transfer to a different charging system was tested immediately after the delayed retention test.

Retention improved with task repetition and deteriorated over the intertest retention interval. Significant ($p < .05$) overall test improvements in task time (20%) and errors (39%) first occurred after three repetitions with no added benefit resulting from a fourth. Transfer was not affected by increased task repetition due to probable floor effects operating on the data. However, transfer was better after task repetition (1-4 repetition groups) than after familiarization alone (0 repetition group).

It was concluded that task repetition during training enhances retention of maintenance skill. Three repetitions are most effective although this number will vary depending on training conditions. Transfer is best when training involves combined test equipment instruction and task performance.

This report is intended for military training personnel.

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Research Report 1271

**EFFECTS OF TRAINING TASK REPETITION
ON RETENTION AND TRANSFER
OF MAINTENANCE SKILL**

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Office, Deputy Chief of Staff for Personnel
Department of the Army

May 1980

Army Project Number
2Q263743A794

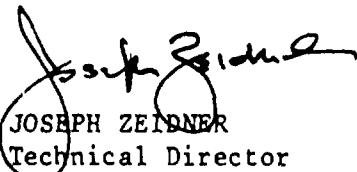
Training and Retention

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FOREWORD

The Training Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) maintains a program of research in support of the systems engineering approach to training. A major focus of this research is the development of fundamental data and technology necessary to field integrated systems for improving individual job performance.

This report is one of a series on specific topics in the area of skill acquisition, retention and transfer. It examines the effect of training task repetition on the retention and transfer of maintenance skill. The work was accomplished by ARI personnel under Army Project 2Q263743A794, FY80, "Education and Training" with the combined support of BG D. W. Stallings, Commanding General and Commandant, and Mr. W. C. Ball, Director, Training Development Directorate, at the US Army Ordnance Center and School, Aberdeen Proving Ground, Maryland.



JOSEPH ZEIDNER
Technical Director

EFFECTS OF TRAINING TASK REPETITION ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

BRIEF

Requirement:

To help guide training course revision efforts of the United States Army Ordnance Center and School (USAOCS) by determining: (1) the relationship between increased training task repetition and the retention and transfer of maintenance skill; and (2) the minimum number of task repetitions necessary to produce substantial maintenance performance benefits.

Procedure:

Five groups of 15 student Fuel and Electrical Repairmen, 63G Military Occupational Specialty (MOS), performed from zero to four repetitions on the training task of testing charging system electrical output using the 500A Sun Test Stand. Each group received test stand familiarization instruction followed by one level of task repetition. Retention was tested both immediately and an average of 14 days after training. Transfer to a different charging system was tested immediately after the delayed retention test. Performance aids were used during the training, retention and transfer phases of the experiment.

Findings:

Combined test retention improved with increased training task repetition. Significant ($p < .05$) improvements in task time (20%) and errors (39%) first occurred after three task repetitions while no additional significant improvement resulted from performance of a fourth repetition. Retention deteriorated over the 14 day intertest interval. However, the relative benefits produced by multiple training task repetition were present at both immediate and delayed retention testing.

Transfer performance was better in terms of both speed and accuracy after task repetition (1-4 repetition groups) than after test stand familiarization instruction alone (0 repetition group). Unlike retention, transfer did not improve with increased training task repetition due to probable floor effects operating on the data.

Utilization of Findings:

Task repetition during training can be viewed as an effective way to enhance retention of maintenance skill. Three repetitions are most effective although it is suggested that this number will vary depending on other training variables such as task difficulty and the type of performance aid used during training. Transfer of maintenance training is most effective when training

involves combined test equipment familiarization instruction and actual task performance. Additional research is needed to determine the training conditions under which task repetition aids transfer. One suggestion involves the addition of equipment variety during training repetitions.

EFFECTS OF TRAINING TASK REPETITION ON THE RETENTION AND TRANSFER OF
MAINTENANCE SKILL

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EFFECTS OF TRAINING TASK REPETITION ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

INTRODUCTION

Two primary goals of the Army are enhanced combat proficiency and an increased combat readiness among its fighting force (Guthrie, 1979). The current trend within the Army toward increased mechanization (Meyer, 1980) has made achievement of these goals more and more dependent upon equipment operability and on the quality of maintenance performed by Army personnel.

It is generally accepted that maintenance throughout the Army must be improved (Gregg, 1979; Johansen, 1979). To accomplish this, the Army has initiated the Maintenance Management Improvement Program. This program has as its primary goal the correction of serious maintenance deficiencies that exist currently within the Army. One suggested way to achieve this goal is to strengthen maintenance training in service school curriculums (Johansen, 1979). To this end, the United States Army Ordnance Center and School (USAOCS) is currently revising its Advanced Individual Training (AIT) program of instruction (POI) for each Military Occupational Specialty (MOS) contained within the Mechanical Maintenance Career Management Field (CMF 63). The objective of this revision process is to increase maintenance training effectiveness as defined by both improved retention of AIT-acquired skill and by enhanced transfer of this skill to post-AIT job performance.

To help guide course revision, information is needed regarding the effects of certain training variables on maintenance task performance. One such variable is task repetition. Interest in task repetition stems from its potential beneficial effect on maintenance training effectiveness and on training time and resource constraints which drive USAOCS course development efforts. The general purpose of the present research was to provide the needed information concerning the effects of task repetition on the retention and transfer of AIT-acquired maintenance skill.

Research evidence suggesting that increased repetition improves task performance is pervasive throughout the literature (e.g., Ellis, 1969; Mandler, 1962; Schendel, Shields & Katz, 1978; Underwood & Keppel, 1963). In general, investigators have shown that increased repetition during training improves the degree of original learning and results in enhanced motor and verbal task retention (e.g., Adams & Dijkstra, 1966; Hellyer, 1962) and transfer (e.g., Duncan, 1953; Postman, 1962; Underwood, 1951). This evidence originates from basic research experiments which have used relatively simple tasks, e.g., word-list learning, and which have not involved the use of performance aids during training. Because maintenance training typically involves relatively complex tasks (e.g., drive train repair) and the use of performance aids (e.g., technical manuals or special training texts), little of what is known about task repetition effects from basic research experiments may apply to Army maintenance training. Thus, one is reluctant to generalize the results of these experiments to maintenance tasks.

Applied research in the area of maintenance training also points to the potential benefits of task repetition. However, much of this work has resulted in training recommendations too vague to answer specific questions of interest to the maintenance training community (e.g., Foley, 1978, p. 5; Vineberg, 1959, p. 44). Two such questions are; does task repetition during training improve the retention and transfer of maintenance skill, and what is the minimum number of task repetitions required to obtain substantial improvement in maintenance performance.

A recent experiment completed by the USAOCS (1979) has provided preliminary information related to these specific questions. In this experiment, the performance of two groups of 63H MOS (Automotive Repairman) was compared. The groups differed in terms of the number of task repetitions received during training. The standard group trained under that standard POI format and received one training trial on each of a large number of critical maintenance tasks. The experimental group trained under an experimental format and received four training trials on each of a more limited number of critical maintenance tasks. Compared to the standard group students, the experimental group students displayed better retention of prior task training and better transfer of this training to new tasks on which they had never been trained. Although these results support the notion that increased task repetition enhances training effectiveness, they must be considered only suggestive due to interpretation difficulties. These difficulties arose because groups differed in ways other than just the number of training task repetitions. For example, they differed systematically in terms of the type of performance aids (technical manuals versus special training texts), the instructional mode (group-paced versus self-paced), the student/instructor ratio (4 to 1 versus 8 to 1), and the student/equipment ratio (2 to 1 versus 6 to 1) used during training. Thus, it could be argued that any one of the differences or combination of differences may have caused the superior performance displayed by the experimental group. In addition, it is not clear whether the same performance benefits could have been realized with fewer than four task repetitions. Thus, additional information is needed to resolve these issues. The present experiment was designed to provide this information.

OBJECTIVES

The specific objectives of the present research were: (1) to isolate the specific relationship between increased training task repetition and the retention and transfer of maintenance skill; and (2) to determine the minimum number of repetitions required to obtain substantial maintenance performance benefits.

METHOD

Subjects

Sixty student Fuel and Electrical Repairmen, 63G MOS, served as subjects. They were randomly selected from the total number of 63G students trained at the USAOCS between 1 October and 1 December 1979.

Design and Procedure

The experiment contained a training and a testing phase as shown in Figure 1. During training, four groups of 15 students performed the experimental task of testing electrical output of the 100 ampere (A) alternator using the 500A Sun Test Stand. A separate group repeated this task from one to four times during training¹. Except for the number of task repetitions, training was identical for all groups. It was instructor-assisted, individualized, performance-oriented training which conformed to current AIT instructional procedures.

Prior to training, all students received general familiarization instruction on test stand operation. This involved explanation of, (1) the purpose and use of the test stand, (2) what each meter measures and how to interpret meter readings in relation to the charging system being tested, (3) the purpose and use of switches and controls critical to testing of alternators and generators, (4) emergency shutdown procedures, and (5) "base settings" of switches and controls and their importance in preventing damage to the test stand and the charging system being tested. Familiarization also included a practical demonstration of a charging system being tested. Training on the 100A alternator began immediately after test stand familiarization. All students were required to use training text materials as performance aids during the training phase of the experiment.

Testing occurred three times after training as shown in Figure 1. The first test was given immediately after the final training repetition. Performance on this test indicated the degree to which students had learned the task. The second test was given an average of 14 days after the first test. The purpose of this test was to examine long-term task retention over a period of no practice. Students used the same performance aids during immediate and delayed retention testing as they did during training. The third test was given immediately after the delayed retention test and was designed to examine whether prior training on the 100A alternator transfers positively to the 60A generator. Thus, transfer was examined using a different charging system while retention was examined using the same charging system as that used during training. Consistent with earlier procedure, training text materials were used as performance aids during transfer testing.

A 4x2 mixed factorial design was used to evaluate retention test performance. The between-Ss variable was task repetitions (1-4) and the within-Ss variable was time of testing (immediate, delayed). Transfer performance was examined using a randomized groups design with task repetitions as the variable of interest. The transfer design contained an additional group of students, as shown in Figure 1. This group (referred to as the 0 repetition group) only received familiarization instruction on test stand operation followed 14 days later by transfer testing on the 60A generator. By comparing the transfer performance of this group with that of the four other repetition groups, it could be determined whether familiarization alone is sufficient to produce transfer or whether prior specific training on a related charging system is necessary. In essence, the 0 repetition group controlled for the effect of test stand familiarization instruction on subsequent transfer

¹Each time through the task is referred to as a repetition.

GROUPS	TRAINING		TESTING		
	TEST STAND FAMILIARIZATION	TASK REPETITIONS	IMMEDIATE RETENTION	DELAYED RETENTION	TRANSFER
0	YES	-	-	-	X
1	YES	A	A	14 DAYS	A
2	YES	AA	A	A	X
3	YES	AAA	A	A	X
4	YES	AAAA	A	A	X

A = 100A ALTERNATOR
 X = 60A ALTERNATOR

Figure 1. Experimental design

performance. Thus, transfer performance was examined using a randomized group design with task repetitions (0-4) as the variable of interest.

Task

The training, retention and transfer tasks contained five major segments; (1) setting of test stand switches and controls to base positions, (2) attachment of generator cables to test stand, (3) setting of test stand switches to positions appropriate for alternator or generator testing, (4) performance of electrical output testing procedures, and (5) performance of test stand shutdown procedures. The specific steps associated with these major segments are listed in USAOCS Special Text (ST) 9-4910-485-12. The relevant portions of this ST adopted for use as training and testing materials on the 100A alternator are shown in Appendix A, while those adopted for transfer testing on the 60A generator are shown in Appendix B.

Equipment

Two models of the Sun Test Stand (AGT9 and AGT9A) were used during training and testing. Both were electrically operated and had the same 10 to 50 volt (V), 50 to 500A direct current (dc) testing range. They differed, however, in their alternating current (ac) range. Model AGT9 had a 25 to 50V, 100 to 500A ac range whereas Model AGT9A had a 25 to 50V, 100 to 400A ac range. Except for this difference, both models were identical. A detailed description of the Sun Test Stand can be found in Technical Manual (TM) 9-4910-485-12.

The 100 amp alternator (Model 5300GT) and the 60 amp generator (Model 3002AE) were both pulley-driven units built by Leece-Neville. The 100 amp alternator was externally rectified and regulated whereas the 60 amp generator was internally rectified and regulated. Both types of charging systems were mounted on test stands by course instructors prior to the start of the experiment.

RESULTS AND DISCUSSION

Retention and transfer test performance was scored for both speed and accuracy. Each performance measure was analyzed separately.

Retention

Speed. Average retention test performance time decreased with increased training task repetitions, as shown in Figure 2. Compared to the time for the 1 repetition group, average combined test time improved 8, 20 and 27% for the 2, 3 and 4 repetitions groups, respectively. Figure 2 also shows that average test time increased over the retention interval between immediate and delayed testing. Averaged over all four groups, this increase was 33%.

To examine the reliability of these findings, a Repetition Group (1-4) by Retention Interval (immediate, delayed) mixed factorial analysis of variance (ANOVA) was performed. This ANOVA revealed a significant main effect of Repetition Group, $F(3, 56) = 4.09$, $p < .05$, and of Retention Interval, $F(1, 56) = 27.72$, $p <$

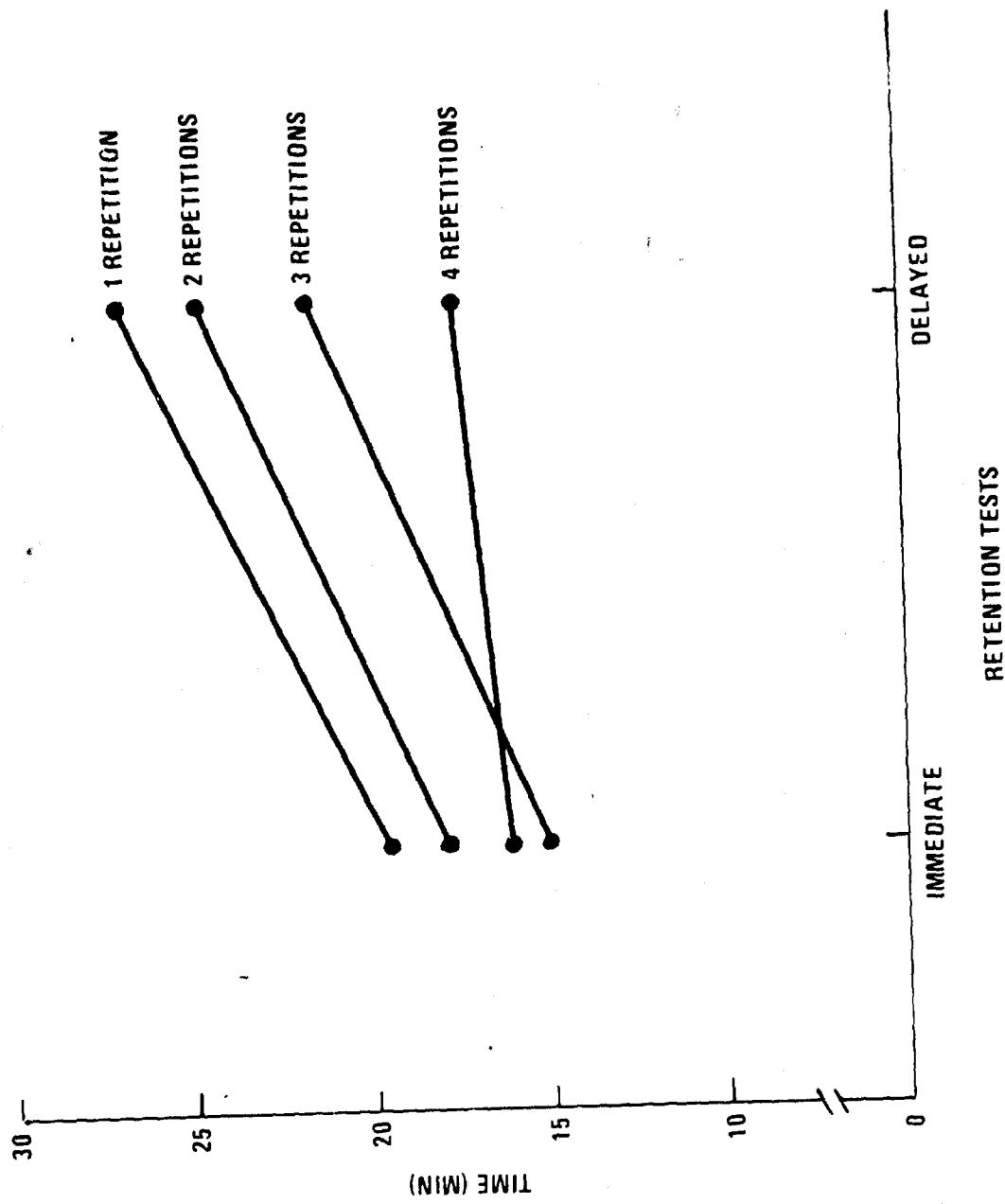


Figure 2. Average performance time obtained at immediate and delayed retention test sessions for four levels of training task repetition.

.05 with no significant interaction of these two variables, $p > .05$. Thus, the improvements in test time due to training repetitions and the decrements in test time due to the retention interval, shown in Figure 2, were both reliable. The apparent difference in retention loss rate over time for the 4 repetitions group was not reliable as indicated by the nonsignificant interaction. Therefore it could have occurred by chance.

As a result of the significant F-value for Repetition Group, individual comparisons were performed using the least significant difference (LSD) method (Carmer & Swanson, 1973). The purpose of these comparisons was to determine the point at which significant performance benefits were obtained as a result of training task repetition. The data for these comparisons are shown in Figure 3. The difference in average test time between 1 and 3 repetitions was significant, $LSD = 4.70$, as was the time difference between 1 and 4 repetitions, $LSD = 6.33$, with $p < .05$ in both cases. Differences in test time between 1 and 2 repetitions and between 3 and 4 repetitions were nonsignificant. Thus, reliable decreases in task performance time were first found at 3 repetitions with no additional benefit resulting from a 4th repetition.

Reexamination of Figure 2 indicated that time differences between groups at delayed testing were present also at immediate testing. If it is accepted that performance at immediate testing indicated the degree of initial task learning, then it can be concluded that the superior delayed retention of the multiple repetition groups was caused by a higher level of initial task learning produced during training. This interpretation supports the often reported finding (e.g., Schendel, et. al., 1979; Singer, 1975, p. 464) that retention is a direct function of the degree of original learning.

Accuracy. Consistent with the findings of previous training research using performance aids (e.g., Horne, 1972; Post, 1970; Serendipity, 1969), the average number of errors committed during testing was low (i.e., 1.32). As shown in Figure 4, errors decreased as a function of added training task repetition and increased over the time between immediate and delayed testing. Compared to the errors for the 1 repetition group, errors for the 2, 3, and 4 repetitions groups decreased 32, 39 and 46%, respectively, whereas the combined group error increase was 72% across the two test sessions.

A Repetition Group (1-4) by Retention Interval (immediate, delayed) ANOVA revealed a significant main effect of Retention Interval, $F(1,56) = 10.45$, $p < .05$, but only a marginally significant main effect of Repetition Group, $F(3,56) = 1.75$, $.10 < p < .20$. Although this latter effect was nonsignificant, a priori expectations regarding the beneficial effects of task repetition justified further analysis of the data via individual comparisons. The data for these comparisons are depicted in Figure 5. As found with time scores, the difference between the average number of errors committed by the 1 and 3 repetition groups was significant, $LSD = .73$, as was this difference for the 1 and 4 repetition groups, $LSD = .86$, with $p < .05$ in both cases. The difference in error between the 1 and 2 repetition

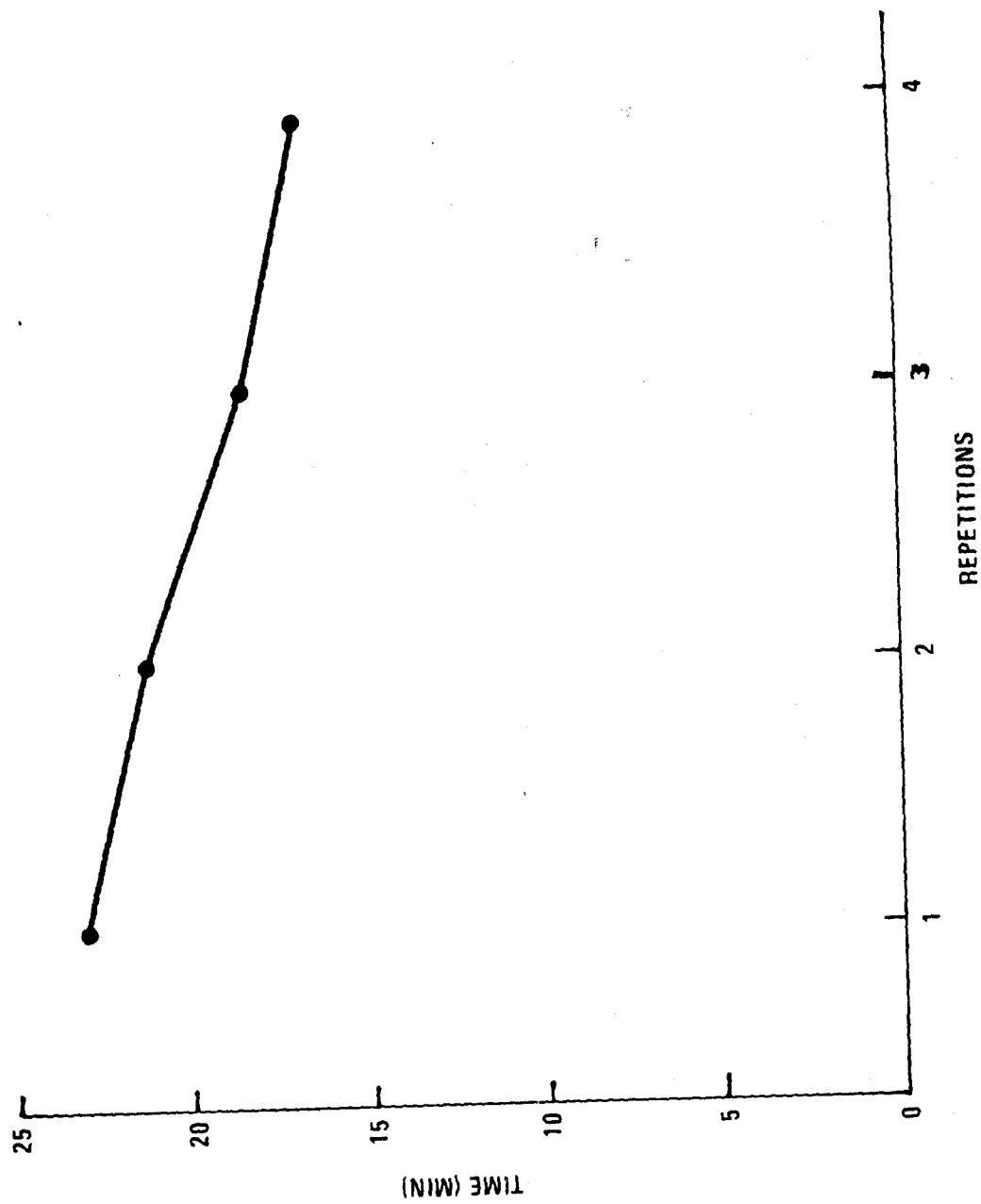


Figure 3. Average combined test performance time for four levels of training task repetition.

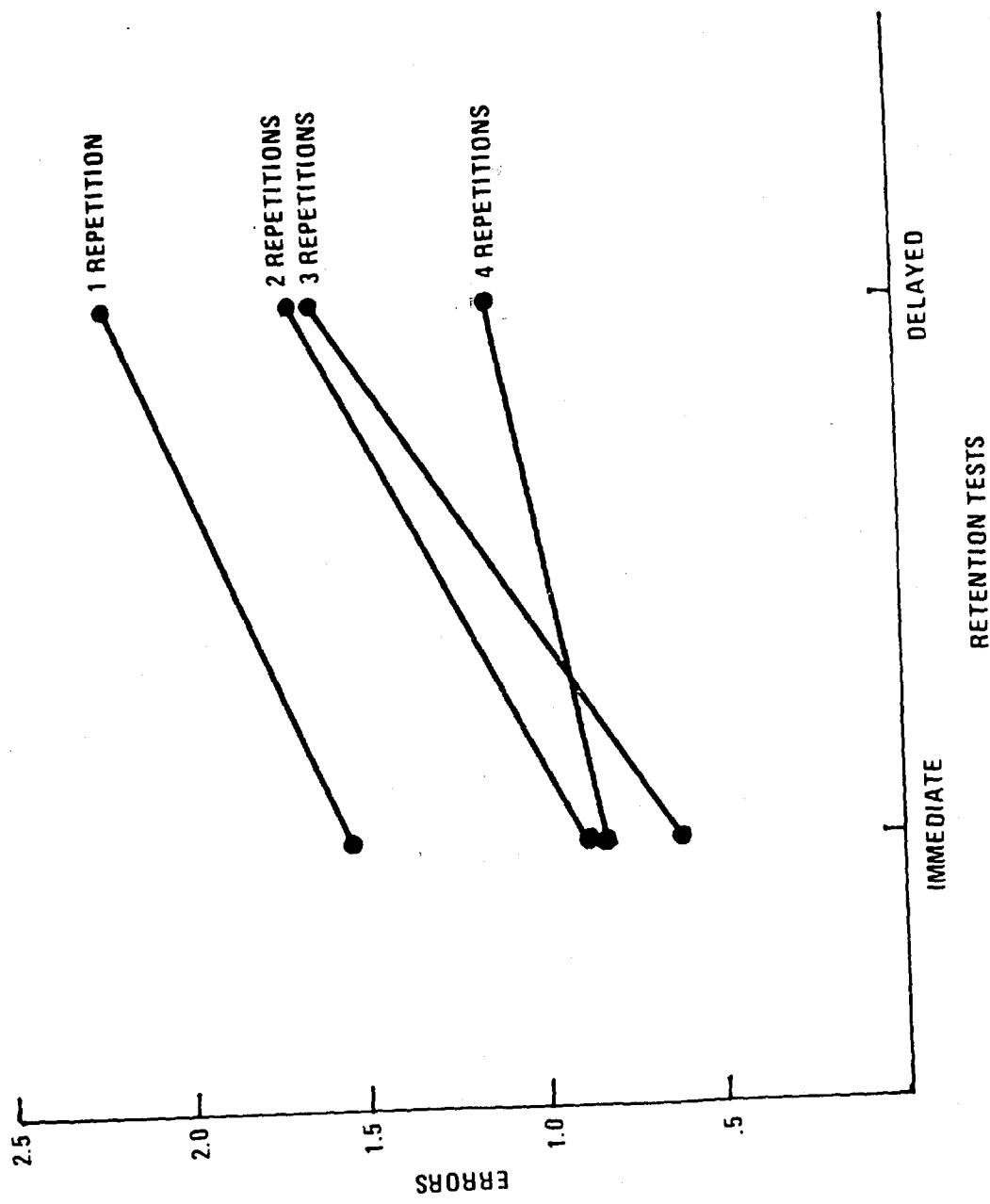


Figure 4. Average number of errors committed at immediate and delayed retention test sessions for four levels of training task repetition.

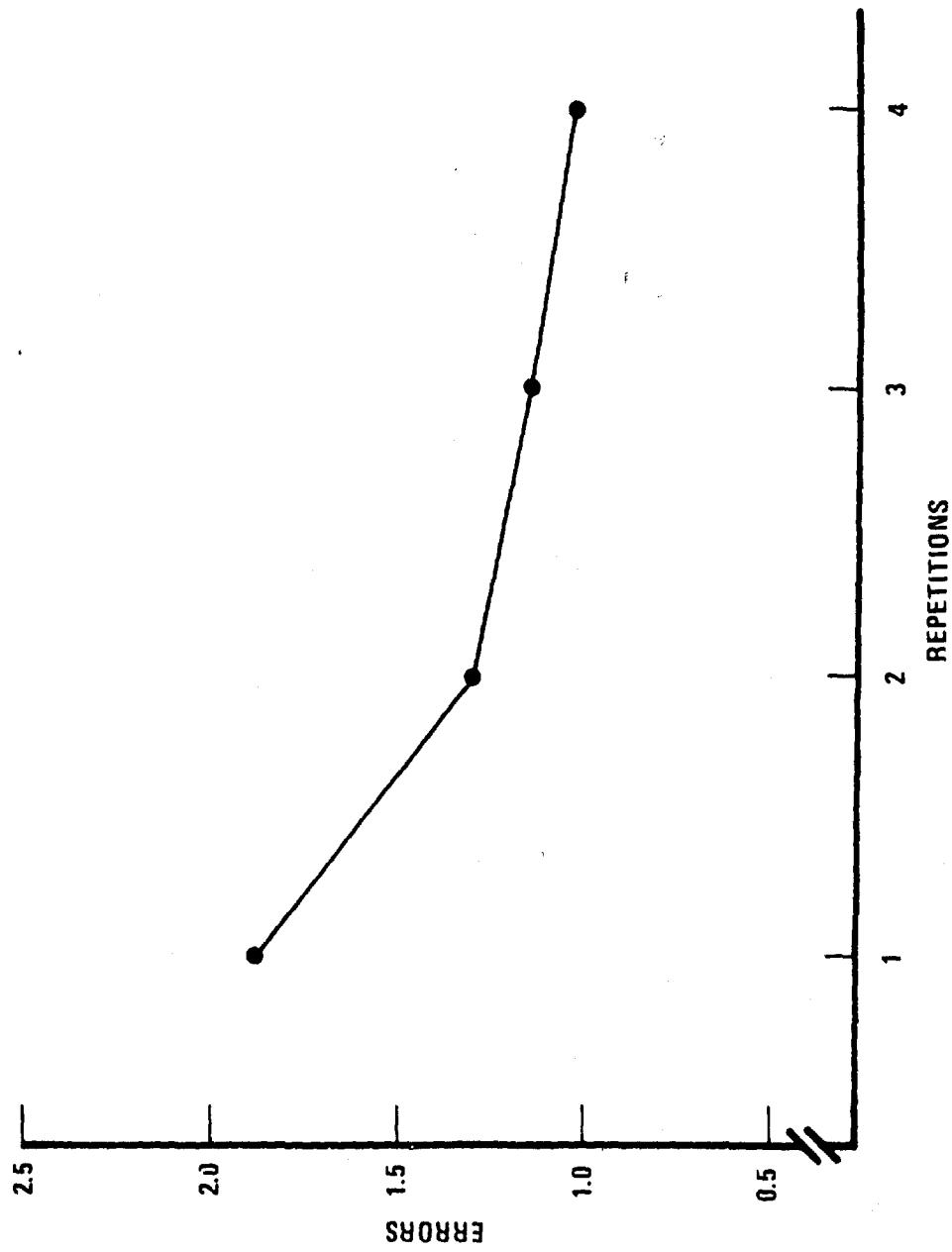


Figure 5. Average combined test errors committed at four levels of training task repetition.

groups and the difference between the 3 and 4 repetition groups were both nonsignificant, $p > .05$. Thus, as found with time scores, significant decreases in errors began to occur at 3 repetitions with no additional benefit resulting from a 4th repetition. Because the differences in errors committed at delayed testing were generally present at immediate testing, retention was a function of the degree of original learning instilled during training. This interpretation is supported by the findings of previous researchers (e.g., Schendel, et. al., 1979) and the time score results of the present experiment.

Task segment errors. The retention task contained five segments as listed in Appendix A. Each segment contained a different number of steps; Base Switch Settings (28), Cable Connections (2), Switch Settings for the Specific Charging System being tested (3), Testing Procedures (11), and Shutdown Procedures (8). Of particular use to the development or revision of any maintenance training curriculum is information concerning the locus of errors committed during task performance. To this end, the number and percentage of total errors committed on each of the five task segments were tallied. Table 1 shows these data for the individual immediate and delayed retention tests as well as for the two tests combined. Combined test data revealed that the majority of errors occurred during performance of the Testing Procedures task segment. A moderate percentage of errors occurred during Setting of Base Switch Positions and during Shutdown procedures whereas a small percentage occurred during Connection of Cables and during Setting of Switch Positions specific to the charging system being tested. Data on the individual test performance revealed that students forgot more information on Testing Procedures than on any other task segment. This was indicated by the substantial increase in the percentage of errors which occurred from immediate to delayed testing for the Testing Procedures segment of the training task. These data indicate that additional training on the Testing Procedures task segment is most needed and would produce the greatest improvements in overall task performance.

The primary reason why errors were most frequently committed during Testing Procedures is that the performance aid instructions for this task segment placed a heavy emphasis on memory whereas those instructions for the other segments did not. For example, during Testing Procedures students needed to remember how to translate certain generally stated instructions such as, "Select load switches to increase present readings to 100A," into the required specific procedural substeps. These substeps were not explicitly stated in the performance aid, and thus, were forgotten. In contrast, instructions such as, "Press STOP button," listed for the other task segments were relatively straightforward and did not require memory for substep translation. Thus, there was little to forget in the task segments which contained these latter types of instructions. In addition to memory for translation of instructions, students also had to remember how to interpret or read meter values. Meter reading was required during Testing Procedures but the exact procedures for doing it were not stated in the performance aid. This forced students to rely entirely on memory for this information. Presumably, this increased dependence on memory for both meter reading and instructional translation provided an added opportunity for performance errors. Thus, performance on the Testing Procedures task segment suffered more than on any other.

TABLE 1
NUMBER AND PERCENTAGE OF TOTAL ERRORS COMMITTED AT IMMEDIATE DELAYED
AND COMBINED RETENTION TESTING ON EACH OF THE FIVE TEST TASK SEGMENTS

		TASK SEGMENTS			Switch Positions			Testing			Shutdown		
		Base	Cable	Switch	for Specific	Charging	System	Procedures	number	percent	number	percent	Procedures
Test	Switch Settings number percent	Connections number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent
Immediate Retention	17	29	1	2	0	0	0	26	45	14	24		
Delayed Retention	19	19	1	1	2	2	2	59	59	19	19		
Combined	36	23	2	1	2	1	1	85	54	33	21		

Assuming the aforementioned reasons are valid, one could improve retention for Testing Procedures by incorporating more detailed performance aid information into the training context. This addition of more fully proceduralized job performance aids would not only reduce memory load for instructional translation, and thereby improve retention, but also reduce overall training time as previously reported (Muller & Joyce, 1974). Aside from the addition of better performance aides, trainers of the task not sufficiently detailed in the performance aid, e.g., meter reading procedures. The present results indicate that one way to improve this memory might be to increase training task repetitions.

Transfer

Transfer was examined to determine whether the number of prior training task repetitions performed on the 100A alternator affected subsequent performance on the 60A generator. Transfer performance was scored for both speed and accuracy with each measure receiving separate analysis.

Speed. Test performance time did not vary inversely with the number of prior training repetitions performed. As shown in Figure 6, average test time remained relatively stable as the number of prior training repetitions increased from one to four. This figure also shows that the 0 repetition group took over twice as much time during testing as any of the other four repetition groups.

To determine the reliability of these observations, a one-way ANOVA was performed on task completion times with prior training repetitions as the independent variable of interest. This ANOVA revealed a significant main effect of task repetition with $F(4,70) = 12.36$, $p < .05$. Subsequent individual comparison tests revealed that the test times for repetition groups 1 through 4 did not differ from one another but that the combined average time for these four groups was faster than that of the 0 repetition group, $LSD = 19.12$, $p < .05$. These findings indicated that providing 0 repetition group students with familiarization information on test stand operation was not sufficient to produce the high level of transfer displayed by the other four groups. Apparently prior training on a charging system, i.e., 100A alternator, similar to that used during transfer testing, i.e., 60A generator, must accompany this familiarization information for effective transfer to occur. However, this prior training need not be extensive in that one repetition was as effective as four.

Accuracy. Error score results were similar to those found for time scores. Figure 7 reveals that errors did not decrease with added training repetitions and that the inferior performance of the 0 repetition group again was apparent. A one-way ANOVA conducted on errors with task repetitions as the independent variable revealed a significant effect of task repetition with $F(4,70) = 3.83$, $p < .05$. Subsequent individual comparisons showed that the number of errors committed by repetition groups 1 through 4 did not differ significantly from one another but that the average error for the four groups combined was greater than that of the 0 repetition group, $LSD = 1.64$, $p < .05$.

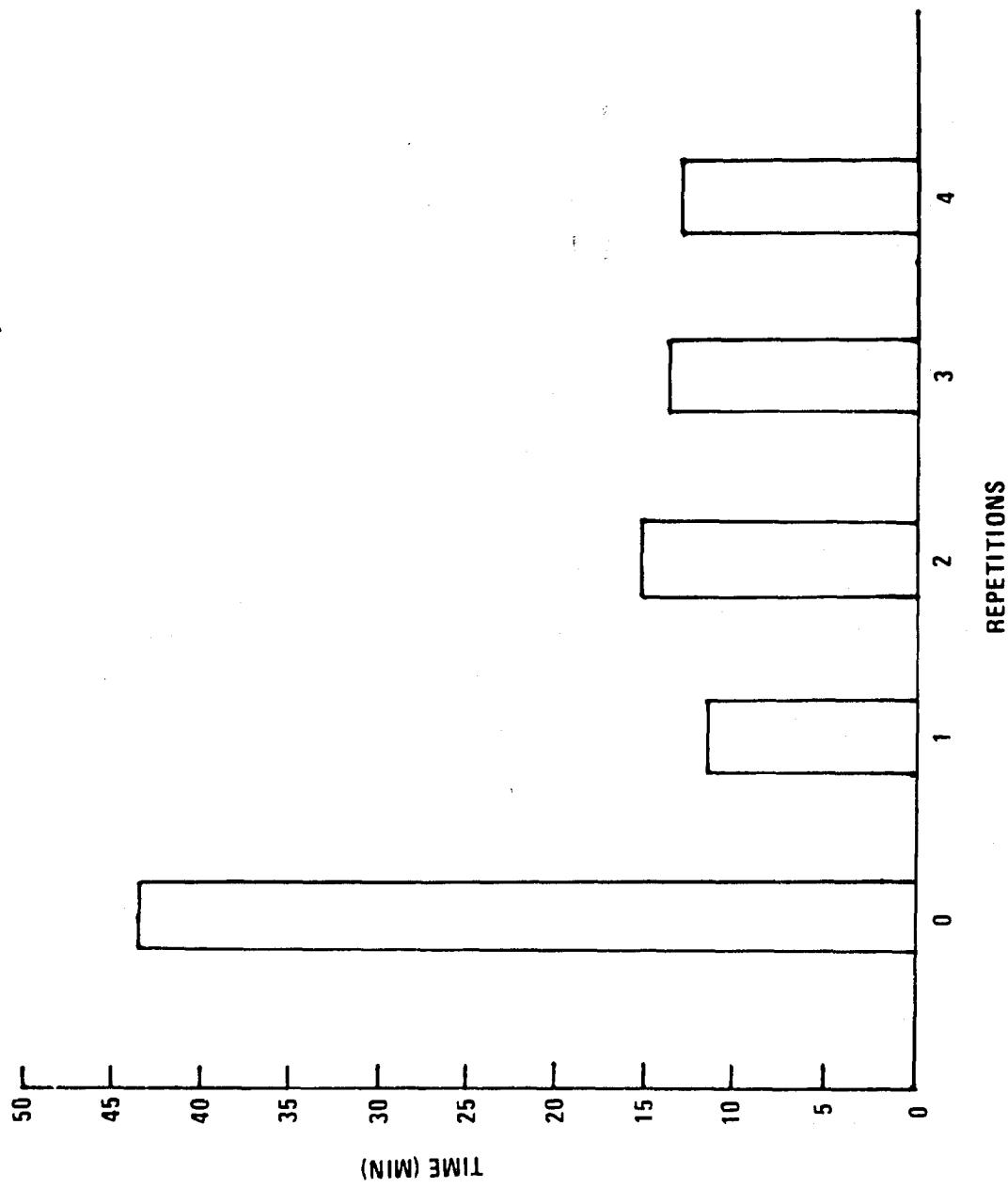


Figure 6. Average performance time obtained at transfer testing for five levels of training task repetition.

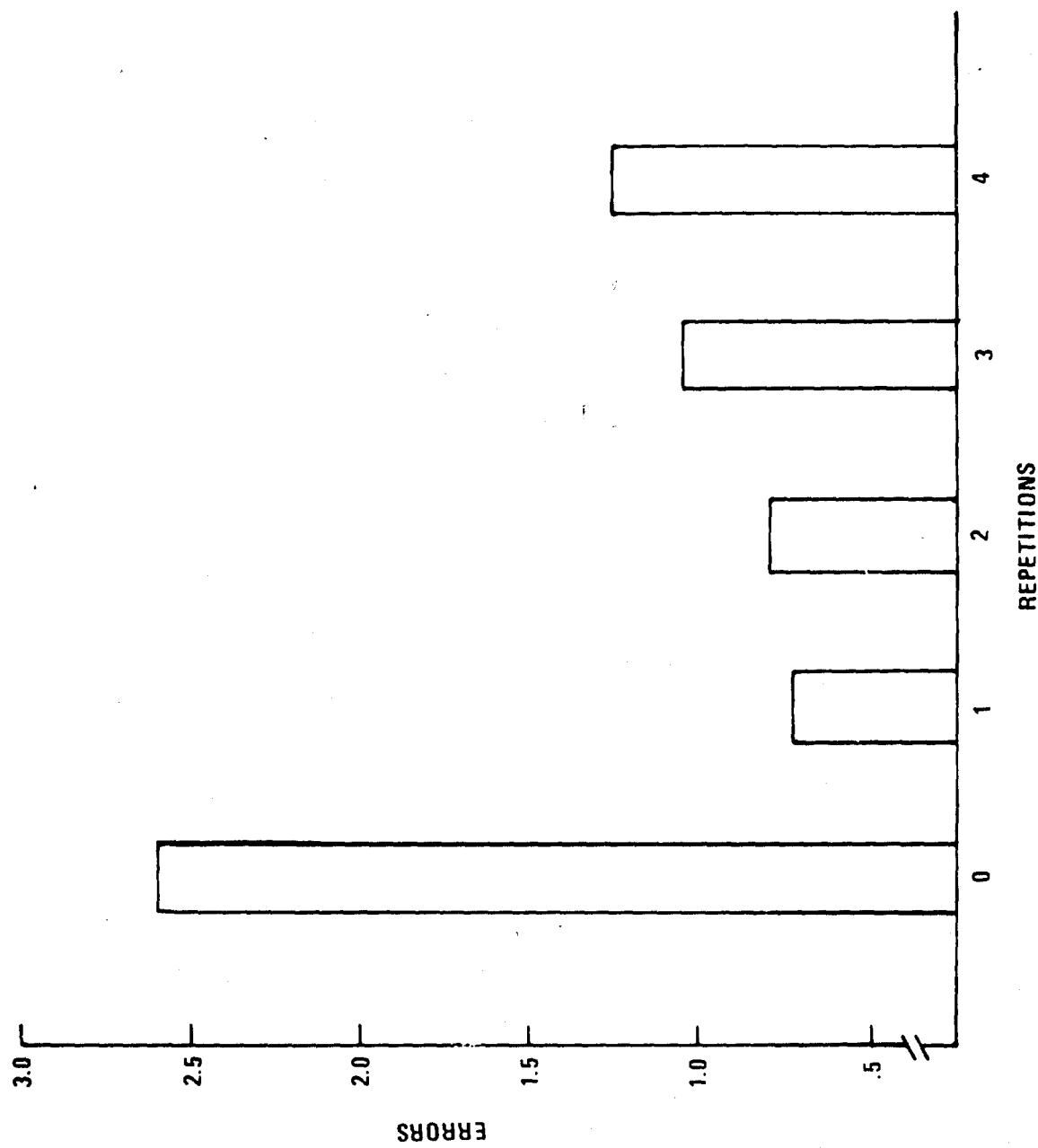


Figure 7. Average number of errors committed at transfer testing for five levels of training task repetition.

Thus, errors did not decrease with added training task repetitions. Only minimal "hands-on training experience plus familiarization information were necessary to produce effective transfer performance. These results support previous recommendations that in order for information received on test equipment operation to be beneficial, use of this information during practice with the actual or related equipment is necessary (Foley, 1978, p. 7).

The lack of a beneficial effect of increased training repetitions on transfer is somewhat inconsistent with classical research findings (e.g., Duncan, 1953). However, transfer performances scores in the present experiment may have been affected by unwanted "floor effects," and therefore, the effect of task repetitions could not be properly evaluated. That is left for additional improvement as training repetitions increased. This is especially true for error scores where the average number of errors committed by the 1 repetition group was less than 1.0.

Besides possible "floor effects" in the data, the lack of increased transfer with increased training repetition may have been due to the lack of task variety experienced by students during training. Although task repetition by itself improves, additional benefits can be derived from the insertion of increased task variety over these repetitions. The result of this type of manipulation has been superior transfer performance under conditions of increased training task variety (e.g., Ellis, Parente, Grah & Spiering, 1975; Williams & Rodney, 1978; Wrisberg & Ragsdale 1979). It is possible that in the present experiment, added training task variety was necessary for the benefits of task repetition to be observed. This issue is currently under investigation (Hagman, in preparation).

Task segment errors. To examine where errors occurred during transfer testing, the number and percentage of errors committed on each of the five transfer task segments (See Appendix B) were recorded. Table 2 shows these scores. The distribution of errors across transfer task segments was similar to that found for retention task segments. Again, the steps listed under the Testing Procedures segment were the most frequently missed. This indicates that an increased training emphasis on Testing Procedures should produce substantial transfer benefits as well as the retention benefits previously mentioned.

SUMMARY AND CONCLUSIONS

The results of the present experiment clarified certain issues concerning the effects of task repetition on retention and transfer of maintenance skill. In doing so, they related directly to the original research objectives.

Maintenance task retention improved in terms of both speed and accuracy as the number of task repetitions performed during training increased. Delayed test performance was a direct function of the level of original learning attained during training. Reliable retention improvements occurred at the third training repetition with no added benefit resulting from execution of a fourth repetition. Thus, future training on the testing of

TABLE 2
NUMBER AND PERCENTAGE OF TOTAL ERRORS COMMITTED AT TRANSFER TESTING
ON EACH OF THE FIVE TEST TASK SEGMENTS

		TASK SEGMENTS			Switch Positions			Testing Procedures			Shutdown Procedures		
Test	number percent	Base Switch Settings	Cable Connections	Charging System	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent	number percent
Transfer	25	26	3	3	2	2	58	60	10	10	10	10	10

charging system electrical output should involve three task repetitions to ensure adequate acquisition and retention. Caution is advised, however, when trying to generalize this finding to other maintenance tasks. Although three repetitions per task may be a good general rule to follow, the specific number of repetitions needed to produce substantial retention effects on other maintenance tasks will depend on a number of task considerations such as; difficulty, quality of performance aid and student memory load. For example, it is suggested that fewer task repetitions should be performed on tasks which are considered easier than the present task and which require less task memorization due to more detailed performance aid information. Task performance time and errors were also found to increase between immediate and delayed testing. Further analysis of the error data revealed that this increase occurred primarily on the Testing Procedures segment of the training task. This indicated that under conditions of limited time availability, this task segment should receive initial training considerations.

In contrast to retention, transfer performance was not a function of prior training task repetitions. The lack of a repetition effect was suggested to be a function of "floor effects" adversely operating on the transfer data or to the need for introduction of added task variety during training repetitions. The most interesting aspect of the transfer data was the finding that general information regarding test equipment operation was not sufficient to produce a high level of transfer. In order for this generally stated knowledge or information to positively affect transfer, students must apply it during actual hands-on practice. Thus, instruction on test equipment operations is most effective if some type of hands-on practice is provided.

Future research on maintenance should address the issues of; (1) whether variety of equipment used during training repetitions improves transfer and (2) whether the method by which repetitions are presented during training affects retention and transfer of maintenance skill.

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APPENDIX A

100 AMP ALTERNATOR - TEST SHEET

TESTS

Immediate Delayed

SECTION I: BASE SETTINGS

Upper Portion of Test Stand

External master power switch.	Off
Main power switch	Off
Motor drive set for CLOCKWISE rotation of generator	
DC load ammeter	.500 amperes
DC field ammeter	.30 amperes
Millivolt meter	9 volts and off
DC voltmeter	50 volts and RECT/GEN
Tachometer	Direct drive
AC ammeter	500 amperes and phase A
AC voltmeter	50 volts and off
400 ampere control box	Voltage adjust full counterclockwise
Equalizer coil test	Off
Ignition switch	Off

Lower Portion of Test Stand

Power supply switch	Off and rheostat fully counterclockwise
Battery charger switch	Off and rheostat full clockwise
External field	Off
Field common	Negative (-)
Field circuit switch	Regulator
Relay lamp	Off
Regulator load resistor selector	Off
Current polarity	Negative (-)
Battery selector	Off
Starter test switch	Off and stator voltage adjust counterclockwise
All load switches	Off
Field current rheostat	Fully counterclockwise
Variable load	Fully counterclockwise

Bus Bars

B+ to G+	
B- to G-	

TESTS

Immediate Delayed

SECTION II: CABLE CONNECTIONS

— — — — — Cable No C548-4102 from alternator connector receptacle to alternator section of test stand

— — — — — Test lead No C548-4100-11 from GVD (regulator section) to D (regulator section)

SECTION III: SPECIFIC SWITCH POSITIONS.

— — — — — DC load ammeter to 150A

— — — — — DC field ammeter to 15A

— — — — — Field circuit switch to MANUAL

SECTION IV: TESTING PROCEDURES

— — — — — Main power switch ON

— — — — — Depress START button and hold 3 to 5 seconds

— — — — — Adjust vari-drive to 2000 rpm

— — — — — Turn battery switch to 24V

— — — — — Turn master load switch ON

— — — — — While watching the DC voltmeter and DC load ammeter, SLOWLY turn the field current rheostat clockwise UNTIL the DC voltmeter reads 28V

— — — — — Select load switches to increase present readings to 100 amps

— — — — — Maintain 28 volts after applying load

— — — — — Take a reading on the AC ammeter. While watching the AC ammeter, rotate the phase selector through A, B, and C positions. 10 amps is the maximum variation allowed between phases.

TESTS

Immediate	Delayed
-----------	---------

While watching the AC voltmeter, rotate the circuit selector through the T1-T2, T1-T3, and T2-T3 positions. One volt is the maximum, variation allowed between circuits

Does alternator meet requirements? YES NO
If No, why not? _____

SECTION V: SHUTDOWN PROCEDURES

_____ Turn field current rheostat fully counterclockwise

_____ Turn master load switch Off

_____ Turn battery switch Off

_____ Reduce vari-drive to 1000 rpm

_____ Press STOP button

_____ Shut main power Off

_____ Return all switches and controls to the base settings

_____ Disconnect all cables and leads and remove generator from test stand

APPENDIX B

TEST 60 Amp Generator - Test Sheet

Transfer

Section I: Base Settings

Upper Portion of Test Stand

External master power switch. Off
Main power switch. Off
Motor drive set for CLOCKWISE
 rotation of generator
DC load ammeter. 500 amperes
DC field ammeter. 30 amperes
Millivolt meter. 9 volts and off
DC voltmeter. 50 volts and RECT/GEN
Tachometer. Direct drive
AC ammeter. 500 amperes and phase A
AC voltmeter. 50 volts and off
400 ampere control box. Voltage adjust full
 counterclockwise
Equalizer coil test. Off
Ignition switch. Off

Lower Portion of Test Stand

Power supply switch. Off and rheostat fully
 counterclockwise
Battery charger switch. Off and rheostat fully
 clockwise
External field. Off
Field common. Negative (-)
Field circuit switch. Regulator
Relay lamp. Off
Regulator load resistor selector. Off
Current polarity. Negative (-)
Battery selector. Off
Starter test switch. Off and stator voltage
 adjust counterclockwise
All load switches. Off
Field current rheostat. Fully counterclockwise
Variable load. Fully counterclockwise

Bus Bars

B+ to G+
B- to G-

PRECEDING PAGE BLANK-NOT FILM

TEST

Transfer

Section II: Cable Connections

Test lead No C548-4100-14 from GND on electrical component to G- on test stand (Generator section)

Test lead No C548-4100-03 from B+ terminal on electrical component to G+ on test stand (Generator section)

Test lead No C548-4100-02 from Ign terminal on electrical component to F on test stand (Generator section)

Test lead No C548-4100-01 from FB regulator section test stand to Ign switch system section test stand.

Section III: Switch Positions

DC load ammeter to 150A.

DC field ammeter to 5A.

Field circuit switch to regulator.

Section IV: Testing Procedures

Main power switch on.

Depress START button and hold down 3 to 5 seconds.

Adjust vari-drive to 2000 rpm.

Calibrate tachometer per paragraph 6.

Place battery selection in the 24V position.

Turn field current rheostat fully CW.

Turn ignition switch on.

Read the DC load ammeter.

Turn master load switch on.

Turn the 0-25A load rheostat CW until the load ammeter reads 60 amps. At this point the DC voltmeter should read 28V.

TEST

Transfer

Does generator meet voltage and amperage requirements?

YES NO

If not, why not? _____

SECTION V: SHUTDOWN PROCEDURES

_____ Turn the master load switch Off

_____ Turn ignition switch Off

_____ Turn the field current rheostat fully counterclockwise

_____ Turn battery selector to Off

_____ Reduce vari-drive to 1000rpm (direct drive)

_____ Press STOP button

_____ Shut main power Off

_____ Return all switches and controls to the base settings

_____ Disconnect all cables and leads and remove generator from test stand (optional)

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